CLAIMS

1. A method for manufacturing a silicon wafer, in which a silicon crystal is pulled from a silicon melt, and a silicon wafer is acquired from the pulled silicon crystal,

wherein the silicon crystal is pulled up by lowering a growth condition V/G_1 (V: growth rate, G_1: axial temperature gradient near a melting point of the silicon crystal) to near a critical value in a state in which the axial temperature gradient G_1 near the melting point of the silicon crystal is increased and a solid-liquid interface, which is a boundary between the silicon crystal and the melt during the pulling of the silicon crystal, is convex with respect to the melt surface.

2. The method for manufacturing a silicon wafer according to Claim 1, wherein a cooler is used to cool the silicon crystal, thereby lowering the growth condition V/G_1 to near the critical value in a state in which the solid-liquid interface is convex with respect to the melt surface within a range in which the growth rate V is from 75 to 97% of Vmax (the limit growth rate at which growth is possible without deformation of the silicon crystal), and the silicon crystal is pulled in which no OSF (oxidation induced stacking fault) region is present anywhere in the plane of the silicon wafer.

3. The method for manufacturing a silicon wafer according to Claim 1, wherein a cooler is used to cool the silicon crystal, thereby lowering the growth condition V/G_1 to near the critical value in the state in which the axial temperature gradient G_1 near the melting point of the silicon crystal is increased.

4. The method for manufacturing a silicon wafer according to Claim 1, wherein a magnetic field is applied to the silicon melt to make the solid-liquid interface convex with respect to the melt surface.

5. The method for manufacturing a silicon wafer according to Claim 1, wherein a cooler is used to cool the silicon crystal, and a rotational speed of the silicon crystal, or a rotational speed of the crucible containing the silicon melt, is adjusted, thereby making the solid-liquid interface convex with respect to the melt surface.

6. A method for manufacturing a silicon wafer, in which a silicon crystal is pulled from a silicon melt, and a silicon wafer is acquired from the pulled silicon crystal,

wherein a cooler is used to cool the silicon crystal, thereby lowering a growth condition V/G_1 to near a critical value in a state in which the axial temperature gradient G_1 near a melting point of the silicon crystal has been increased, and

the silicon crystal is pulled in which no OSF (oxidation induced stacking fault) region is present in a plane of the silicon wafer at least from a center of the plane up to 10 mm from an outer periphery.

7. The method for manufacturing a silicon wafer according to Claim 6, wherein an oxygen concentration in the silicon crystal is controlled to be not more than 12.5×10^{17} atoms/cm^3 (Year 1979 ASTM).

8. The method for manufacturing a silicon wafer according to Claim 6, wherein the silicon wafer is subjected to heat treatment at 1000°C or higher so that OSF nuclei will not materialize as OSFs in the silicon wafer.

9. The method for manufacturing a silicon wafer according to Claim 6, wherein the silicon wafer is subjected to heat treatment at 1000°C or higher in a non-oxidative atmosphere so that OSF nuclei will not materialize as OSFs in the silicon wafer and so that void defects will be eliminated in the silicon wafer surface layer.

10. An apparatus for manufacturing a silicon wafer, with which a silicon crystal is pulled from a silicon melt by a pulling mechanism, and the silicon wafer is acquired from the pulled silicon crystal,

wherein a cooler for cooling the silicon crystal is provided above the silicon melt, and

a silicon crystal pulling rate by the pulling mechanism and an amount of cooling by the cooler are adjusted,

thereby lowering a growth condition V/G_1 (V: growth rate, G_1: axial temperature gradient near a melting point of the silicon crystal) to near a critical value in a state in which the axial temperature gradient G_1 near the melting point of the silicon crystal is increased and a solid-liquid interface, which is a boundary between the silicon crystal and the melt during the pulling of the silicon crystal, is convex with respect to a melt surface,

and the silicon crystal is pulled up.

11. The apparatus for manufacturing a silicon wafer according to Claim 10, wherein the cooler is used to cool the silicon crystal, thereby lowering the growth condition V/G_1 to near the critical value in the state in which the solid-liquid interface is convex with respect to the melt surface within a range in which the growth rate V is from 75 to 97% of Vmax (a limit growth rate at which growth is possible without deformation of the silicon crystal),

and the silicon crystal is pulled in which no OSF (oxidation induced stacking fault) region is present anywhere in a plane of the silicon wafer.

12. An apparatus for manufacturing a silicon wafer, in which a silicon crystal is pulled from a silicon melt, and the silicon wafer is acquired from the pulled silicon crystal,

wherein a cooler for cooling the silicon crystal is provided above the silicon melt, and

a silicon crystal pulling rate by the pulling mechanism and an amount of cooling by the cooler are adjusted,

thereby lowering a growth condition V/G_1 to near a critical value in a state in which an axial temperature gradient G_1 near a melting point of the silicon crystal has been increased, and

the silicon crystal is pulled in which no OSF (oxidation induced stacking fault) region is present in a plane of the silicon wafer at least from a center of the plane up to 10 mm from an outer periphery.

13. The apparatus for manufacturing a silicon wafer according to Claim 10, wherein the cooler is disposed so as to surround the silicon crystal at a distance of 30 to 500 mm from the silicon melt.

14. The apparatus for manufacturing a silicon wafer according to Claim 12, wherein the cooler is disposed so as to surround the silicon crystal at a distance of 30 to 500 mm from the silicon melt.

15. The apparatus for manufacturing a silicon wafer according to Claim 10, wherein a heat shield is provided above the silicon melt, and a gap between a lower end of the heat shield and the silicon melt surface is set to between 20 and 100 mm.

16. The apparatus for manufacturing a silicon wafer according to Claim 12, wherein a heat shield is provided above the silicon melt, and a gap between a lower end of the heat shield and the silicon melt surface is set to between 20 and 100 mm.

17. A silicon wafer, acquired by pulling from a silicon melt,

wherein no OSF (oxidation induced stacking fault) region is present anywhere in a plane of the silicon wafer, an average void defect density over the entire plane of the silicon wafer is not more than $5 \times 10^6/cm^3$, and an average void defect size over the entire plane of the silicon wafer is not more than 100 nm.

18. A silicon wafer, acquired by pulling from a silicon melt,

wherein no OSF (oxidation induced stacking fault) region is present in a plane of the silicon wafer at least from a center of the plane up to 10 mm from an outer periphery, an average void defect density in the plane of the silicon wafer at least from a center of the plane up to 10 mm from an outer periphery is not more than $5 \times 10^6/cm^3$, and an average void defect size is not more than 100 nm.

19. A method for manufacturing a defect-free silicon single crystal in which void defects, OSFs (oxidation induced stacking faults), and dislocation clusters (interstitial silicon dislocation defects) have been eliminated by setting a carbon concentration to 3×10^{15} atoms/cm^3 or less and adjusting a growth condition V/G (V: growth rate, G: axial temperature gradient of the crystal).

20. A defect-free silicon single crystal in which void defects, OSFs (oxidation induced stacking faults), and dislocation clusters (interstitial silicon dislocation defects) have been eliminated, manufactured by setting a carbon concentration to 3×10^{15} atoms/cm^3 or less and adjusting a growth condition V/G (V: growth rate, G: axial temperature gradient of the crystal).

21. An apparatus for pulling a silicon single crystal, comprising: a single crystal pulling chamber in which a carrier gas is supplied from above and exhausted from below; a crucible that is provided inside the single crystal pulling chamber, and into which a raw material is supplied and melted; and a heat shield that is disposed above the

crucible, for guiding the carrier gas to a melt surface inside the crucible, in which the silicon single crystal is pulled from the melt inside the crucible,

wherein the heat shield can be raised and lowered,

the heat shield is positioned where a carbon concentration inside the pulled silicon single crystal is 3×10^{15} atoms/cm^3 or less, and

the silicon single crystal is pulled while a growth condition V/G (V: growth rate, G: axial temperature gradient of the crystal) is adjusted such that void defects, OSFs (oxidation induced stacking faults), and dislocation clusters (interstitial silicon dislocation defects) are eliminated from the pulled silicon single crystal.